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Science 10

Course Outcomes

Resource Development Draft

August 2001

The Resource Development Draft incorporates revisions based on the May 1999 review of the second (validation) draft. Further minor adjustments to the course outcomes may be made following field testing in February – May 2003.

Unit Organization

In Grades 7–9, five units of study are outlined at each grade level. At grades 10–12, four units of study are outlined for each grade level. Each unit includes the following components.

Unit Overview

Each unit of study begins with an overview that introduces the contents of the unit and suggests an approach to its development.

Focussing Questions

These questions frame a context for introducing the unit and suggest a focus for investigative activities and application of ideas by students.

Key Concepts

Key concepts identify major ideas to be developed in each unit. Some of the key concepts may be addressed in additional units at the same grade/course level, as well as at other grade/course levels. The intended scope of treatment of these concepts is indicated by the learner outcomes.

Outcomes

Two levels of outcomes are provided in the draft program and courses of study:

- **General Outcomes:** These are the major outcomes for each unit. For STS and knowledge, the outcomes are combined and unique to each unit. For skills and attitudes, the outcomes are common to all units.
- **Specific Outcomes:** These are detailed outcomes that flesh out the scope of each unit. They are shown in bulleted form.

Examples

Many of the outcomes are supported by examples. The examples **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed. Illustrative examples are written in *italics* and separated from the outcomes by being placed in parentheses.

Unit Emphases

Each unit of study in secondary science begins with an overview and a set of focussing questions that identify a context for study. In defining the context, one of the following areas of emphasis is identified for each unit.

- *Nature of Science* emphasis: In these units student attention is focused on the processes by which scientific knowledge is developed and tested, and on the nature of the scientific knowledge itself. Skills emphasized in these units are the skills of scientific inquiry.
- *Science and Technology* emphasis: In these units students seek solutions to practical problems by developing and testing prototypes, products and techniques to meet a given need. The skills emphasized are those of problem solving, in combination with the skills of scientific inquiry.
- *Social and Environmental Contexts* emphasis: In these units student attention is focused on issues and decisions relating to how science and technology are applied. Skill emphasis is on the use of research and inquiry skills to inform decisions; students seek and analyze information and consider a variety of perspectives.



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Unit A: Energy and Matter in Chemical Change (*Nature of Science emphasis*)

Overview: Chemical changes involve energy and transformations of matter. A knowledge of the underlying structure of matter and the basic chemical species is important in understanding chemical change. As students explore the properties of molecular and ionic compounds, including acids and bases, they begin to appreciate the need for a classification scheme and a system of nomenclature. Students expand their knowledge of chemistry from Science 9 to name compounds, classify, and write balanced chemical equations to represent chemical changes. As well, students are introduced to the law of conservation of mass, and the mole concept.

Focussing Questions: How has knowledge of the structure of matter led to other scientific advancements? How do elements combine, and can these combinations be classified and the products be predicted and quantified? Why do scientists classify chemical change, follow guidelines for nomenclature and represent chemical change by equations?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- | | |
|--|---|
| ☆ chemical substances and human needs | ☆ evidence for chemical change |
| ☆ WHMIS and safe practices | ☆ role and need for classification of chemical change |
| ☆ International Union of Pure and Applied Chemistry (IUPAC) nomenclature, ionic and molecular compounds, acids and bases | ☆ writing and balancing equations |
| | ☆ law of conservation of mass and the mole concept |

STS and Knowledge Outcomes

Students will:

1. Describe the basic particles that make up the underlying structure of matter, and investigate related technologies
 - provide examples of how early humans worked with chemical substances to meet their basic needs (*e.g., the use of dyes and smelting of ores by North American aboriginals*)
 - outline the role of evidence in the development of the atomic model; i.e., Dalton, Thomson, Rutherford, Bohr
 - provide examples of chemistry-based careers in their community (*e.g., chemical engineering, cosmetology, food processing*).
2. Explain, using the periodic table, how elements combine to form compounds, and follow IUPAC guidelines for naming ionic compounds and simple molecular compounds
 - illustrate an awareness of WHMIS guidelines, and demonstrate safe practices in handling, storing and disposing of chemicals in the laboratory and at home
 - explain the importance of and the need for the IUPAC system of naming compounds, in terms of the work that scientists do and the need to communicate clearly and precisely
 - explain, using the periodic table, how and why elements combine to form compounds in specific ratios
 - predict formulas and write names for ionic and molecular compounds and common acids (*e.g., sulfuric, hydrochloric, nitric, ethanoic*), using a periodic table, a table of ions and IUPAC rules
 - classify, ionic and molecular compounds, and acids and bases on the basis of their properties, i.e., conductivity, pH, solubility, and state
 - predict whether an ionic compound is relatively soluble in water, by consulting a solubility chart

- relate the molecular structure of simple substances to their properties (*e.g., describe how the properties of water are due to the polar nature of the water molecule, and relate this property to the transfer of energy in physical and living systems*)
 - outline the issues related to personal and societal use of potentially toxic or hazardous compounds (*e.g., health hazards due to excessive consumption of alcohol and nicotine; exposure to toxic substances; environmental concerns related to the handling, storage, and disposal of heavy metals, strong acids, flammable gases, volatile liquids*).
3. Identify and classify chemical changes, and write word and balanced chemical equations for significant chemical reactions, as applications of Lavoisier's law of conservation of mass
- provide examples of household, commercial and industrial processes that use chemical reactions to produce useful substances and energy (*e.g., baking powder in baking, combustion of fuels, electrolysis of water into water in $H_{2(g)}$ and $O_{2(g)}$*)
 - identify chemical reactions that are significant in our society (*e.g., reactions that maintain living systems, such as photosynthesis and respiration; reactions that have an impact on the environment, such as combustion reactions*)
 - describe the evidence for chemical changes; i.e., energy change, formation of a gas or precipitate, colour or odour change, change in temperature
 - differentiate between endothermic and exothermic chemical reactions (*e.g., combustion of gasoline, photosynthesis*)
 - classify and identify categories of chemical reactions; i.e., formation (synthesis), decomposition, hydrocarbon combustion, single replacement, double replacement
 - translate word equations to balanced chemical equations and vice versa for chemical reactions that occur in living and nonliving systems [**Prerequisite Skills: Grade 7 Mathematics, Strand: Number, SO 20, and Grade 8 Mathematics, Strand: Patterns and Relations, SO 3**]
 - predict the products of formation (synthesis) and decomposition, single and double replacement, and hydrocarbon combustion chemical reactions, given the reactants [**Prerequisite Skills: Grade 8 Mathematics, Strand: Number, SOs 12 and 15**]
 - define the mole as the amount of an element containing 6.02×10^{23} atoms (Avagadro's number), and apply the concept to calculate quantities of substances made of other chemical species (*e.g., determine the quantity of water that contains 6.02×10^{23} molecules of H_2O*) [**Prerequisite Skills: Grade 8 Mathematics, Strand: Number, SO 15**]
 - interpret balanced chemical equations in terms of moles of chemical species, and relate the mole concept to the law of conservation of mass [**Prerequisite Skills: Grade 7 Mathematics, Strand: Number, SO 20**].

Skill Outcomes (*focus on scientific inquiry*)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- define and delimit problems to facilitate investigation
- design an experiment, identifying and controlling major variables (*e.g., design an experiment to differentiate between categories of matter, such as acids, bases, and neutral solutions, and identify manipulated and responding variables*)
- state a prediction and hypothesis based on available evidence and background information (*e.g., hypothesize as to what happens to baking soda during baking*)

- evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring and decision making (e.g., *list appropriate instruments and apparatus that may be required to classify compounds such as litmus paper or conductivity tester*).

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures where required (e.g., *when performing an experiment to illustrate conservation of mass, demonstrate an understanding of closed and open systems and control for loss or gain of matter during a chemical change*)
- use library and electronic research tools to collect information on a given topic (e.g., *information on compounds we use and their toxicity, using standard references such as the Merck Index, as well as Internet searches*)
- select and integrate information from various print and electronic sources or from several parts of the same source (e.g., *collect information on research into subatomic matter, such as neutrinos*)
- demonstrate a knowledge of WHMIS standards, by selecting and applying proper techniques for handling and disposing of laboratory materials (e.g., *recognize and use MSDS information*)
- select and use apparatus, technology and materials safely (e.g., *use equipment, such as Bunsen burners, electronic balances and laboratory glassware, electronic probes, and calculators correctly and safely*).

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- describe and apply classification systems and nomenclature used in the sciences (e.g., *investigate periodicity in the periodic table classify matter, and name elements and compounds based on IUPAC guidelines*)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (e.g., *compare models for the structure of the atom*)
- compare theoretical and empirical values and account for discrepancies (e.g., *measure the mass of a chemical reaction system before and after a change, and account for any discrepancies*)
- identify and explain sources of error and uncertainty in measurement, and express results in a form that acknowledges the degree of uncertainty (e.g., *measure and record the mass of a material*)
- identify new questions or problems that arise from what was learned (e.g., *how did ancient peoples find out how to separate metals from their ores?*).

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others (e.g., *use appropriate communication technology to elicit feedback from others*)

- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results (*e.g., use appropriate SI notation, IUPAC nomenclature*).

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not (*e.g., recognize the usefulness of being skilled at mathematics and problem solving; appreciate how scientific problem solving and the development of new technologies are related*)
- value the contributions to scientific and technological development made by men and women from many societies and cultural backgrounds (*e.g., recognize the research of Canadians, both men and women in science*).

Interest in Science

Students will be encouraged to:

- consider further studies and careers in science- and technology-related fields (*e.g., recognize that part-time jobs require science- and technology-related knowledge and skills*).

Scientific Attitudes

Students will be encouraged to:

- use factual information and rational explanations when analyzing and evaluating (*e.g., critically evaluate inferences and conclusions*)
- value the processes for drawing conclusions (*e.g., critically assess their opinion of the value of science and its applications*).

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas (*e.g., willingly work with any classmate or group of individuals, regardless of their age, gender, or physical and cultural characteristics; assume a variety of roles within a group, as required; accept responsibility for any task that helps the group complete an activity*).

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations (*e.g., safely handle and dispose of chemicals; use equipment, such as hot plates and laboratory glassware, correctly and safely*)
- be aware of the direct and indirect consequences of their actions (*e.g., acknowledge the need for safe methods for handling and disposing of potentially hazardous materials in the home and laboratory*).

Unit B: Energy Flow in Technological Systems (*Science and Technology emphasis*)

Overview: The first and second laws (conservation and conversion) of thermodynamics have been useful in the development of modern and efficient energy conversion devices. Students investigating mechanical energy conversions and transfers in systems will recognize that while energy is conserved, useful energy diminishes with each conversion. As well, students will understand that energy can only be observed when transferred, and also that mechanical energy can be quantified. The Energy conservation and conversion concepts, introduced in Science 9, Unit D: Electrical Interactions and Innovations, and the operational understanding of force and work developed in Science 8, Unit D: Mechanical Systems, are applied by students to explain energy conversions in natural and technological systems; and in investigating the design and function of energy conversion technologies.

Focussing Questions: Which came first: science or technology, and is it possible for technological development to take place without help from “pure” science? How did efforts to improve the efficiency of heat engines result in the formulation of the first and second law of thermodynamics? Why are efficiency and sustainability important considerations in designing energy conversion technologies?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- | | |
|--|---|
| ☆ technological innovations of engines leading to the development of the concept of energy | ☆ design and function of technological systems and devices involving potential and kinetic energy, and thermal energy conversions |
| ☆ forms and interconversions of mechanical energy, and “useful” energy | ☆ efficient use of energy, and environmental impact of inefficient use of energy |
| ☆ one-dimensional scalar motion, and scalar mechanical energy conversions and work done | |

STS and Knowledge Outcomes

Students will:

1. Analyze and illustrate how technologies based on thermodynamic principles were developed before the laws of thermodynamics were formulated
 - relate the processes of trial and error leading to the invention of the engine and the subsequent development of the principles of thermodynamics from attempts to improve efficiency (*e.g., the role of James Watt, valve design in automobile engines*)
 - illustrate, by use of examples from natural and technological systems, that energy exists in a variety of forms (*e.g., mechanical, chemical, thermal, nuclear, solar*)
 - analyze and illustrate how the concept of energy developed from observation of heat and mechanical devices (*e.g., the investigations of Rumford and Joule*)
 - describe, qualitatively, current technologies used to transform energy from one form to another, and that energy transfer technologies produce measurable changes in motion, shape or temperature (*e.g., hydroelectric and coal-burning generators, solar heating panels, windmills, fuel cells*).
2. Explain and apply concepts used in theoretical and practical measures of energy in mechanical systems
 - describe the evidence for energy as an observable change, including physical and chemical, and changes to motion, shape and temperature

- define kinetic energy as change in energy due to motion, and define potential energy as energy due to relative position or condition
 - recognize that (potential) energy is “useful” only when it can be converted from one form to another (*e.g., potential energy to kinetic energy, chemical energy to thermal or electrical energy, electrical energy to thermal energy*)
 - describe acceleration qualitatively (*e.g., change of speed over an interval of time; speeding up, slowing down*), and extending from Science 8, operationally define force as push or pull and work done as energy expended when the speed of an object is increased, or when an object is moved against the influence of an opposing force
 - define gravitational potential energy as the work done on lifting a mass against gravity
 - extend from Unit A to describe chemical energy as a form of potential energy (*e.g., energy stored in glucose, ATP, gasoline*)
 - define extending from Science 8, energy as the property of a system that is a measure of its capacity for doing work, and define work done as transfer of energy by mechanical means
 - quantify gravitational potential energy, using $E_p = mgh$, kinetic energy, using $E_k = \frac{1}{2}mv^2$, work done, using $W = Fd$, and speed, using $v = d/t$ [**Prerequisite Skills: Grade 8 Mathematics, Strand: Patterns and Relations, SOs 4 to 6 for $E_p = mgh$, $W = Fd$, and $v = \frac{d}{t}$ and Grade 9 Mathematics, Strand: Number, SO 3 for $E_k = \frac{1}{2}mv^2$**]
 - derive the SI unit of energy and work, the Joule, from fundamental units [**Prerequisite Skill: Grade 8 Mathematics, Strand: Number, SO 14**]
 - investigate and analyze one-dimensional scalar motion and work done on an object or system, using algebraic and graphical techniques (*e.g., the relationships among distance, time and speed; determining area under line in a force–distance graph*) [**Prerequisite Skills: Grade 7 Mathematics, Strand: Patterns and Relations, SOs 2 to 6 and Grade 8 Mathematics, Strand: Patterns and Relations, SOs 2 and 3**].
3. Apply principles of energy conservation and thermodynamics in investigating, describing and predicting efficiency of energy transformation in technological systems
- describe qualitatively, and in terms of thermodynamic laws, the energy transformations occurring in devices and systems (*e.g., automobiles, bicycles coming to a stop, thermal power plant, food chain, refrigerator, heat pump*)
 - describe how the first and second law of thermodynamics have changed our understanding of energy conversions (*e.g., why heat engines are not 100% efficient*)
 - define, operationally, “useful” energy from a technological perspective, and analyze the stages of “useful” energy transformations in technological systems (*e.g., hydroelectric dam*)
 - explain quantitatively, efficiency as a measure of the useful work compared to the total energy put into an energy conversion process or device
 - apply concepts related to efficiency of thermal energy conversion to analyze the design of a thermal device (*e.g., heat pump, high efficiency furnace, automobile engine, in order to maximize overall efficiency and minimize ecological damage*)
 - compare the energy content of fuels used in thermal power plants in Alberta, in terms of costs, benefits, efficiency and sustainability
 - explain the need for efficient energy conversions in protecting our environment and making judicious use of natural resources (*e.g., co-generation of electricity and heat*).

Skill Outcomes (focus on problem solving)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- design an experiment, identifying and controlling major variables (*e.g., design an experiment to demonstrate the conversion of chemical potential energy to thermal energy, involving a combustion reaction; this example is also applicable to Unit 1*)
- formulate operational definitions of major variables (*e.g., predict or hypothesize the conversion of energy from potential form to a kinetic form, in an experiment using a pendulum or free fall*).

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures where required (*e.g., perform an experiment to demonstrate the equivalency of work done on an object, and resulting kinetic energy; design a device that converts mechanical energy into thermal energy*)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (*e.g., use computer-based laboratory to compile and organize data from an experiment to demonstrate the equivalency of work done on an object, and resulting kinetic energy*) [**Prerequisite Skill: Grade 9 Mathematics, Strand: Statistics and Probability, SO 1**]
- use library and electronic research tools to collect information on a given topic (*e.g., compile information on energy content of fuels used in Alberta power plants; trace the flow of energy from the Sun to the lighting system in the school, identifying what changes are taking place at each stage of the process*)
- select and integrate information from various print and electronic sources or from several parts of the same source (*e.g., create multiple-linked documents on using alternative energy sources to generate electricity in Alberta*)
- relate the development of power sources, in particular effective engines, to the industrial revolution and to present day first world economics.

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compile and display evidence and information, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots (*e.g., plot distance–time and force–distance graphs; manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets*) [**Prerequisite Skills: Grade 9 Mathematics, Strand: Statistics and Probability, SOs 1 to 5; Corequisite Skills: Applied Mathematics 10, SOs 2.7–2.8, 3.1, 3.3, and Pure Mathematics 10, SOs 1.5–1.6, 3.1, 4.2**]
- identify limitations of data or measurement (*e.g., measure of local value of gravity varies globally, use significant digits appropriately*)
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables (*e.g., interpret a graph of changing kinetic and potential energy from a*

pendulum during one-half period of oscillation; calculate slope of the line in a distance–time graph; calculate area under the line in a force–distance graph) [Prerequisite Skills: Grade 7 Mathematics, Strand: Patterns and Relations, SOs 2 to 6, and Grade 8 Mathematics, Strand: Patterns and Relations, SOs 2 and 3; Corequisite Skills: Applied Mathematics 10 SOs 4.3, 5.2 and Pure Mathematics 10 SO 3.4]

- compare theoretical and empirical values and account for discrepancies (*e.g., determine the efficiency of thermal energy conversion systems*) [Prerequisite Skill: Grade 7 Mathematics, Strand: Number, SO 18]
- provide a statement that addresses the problem or answers the question investigated, in light of the link between data and the conclusion (*e.g., explain the discrepancy between theoretical and actual efficiency of a thermal energy conversion system*)
- construct and test a prototype of a device or system, and troubleshoot problems as they arise (*e.g., design and build an energy conversion device*)
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (*e.g., assess whether coal or natural gas should be used to fuel thermal power plants in Alberta*)
- evaluate a personally designed and constructed device on the basis of criteria they have developed themselves (*e.g., evaluate an energy conversion device*).

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results (*e.g., use appropriate SI notation, fundamental and derived units; use advanced menu features within a word processor to accomplish a task, to insert tables, graphs, text and graphics*) [first example Prerequisite Skill: Grade 8 Mathematics, Strand: Number, SO 14]
- work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise (*e.g., develop a plan to build an energy conversion device, seek feedback, test and review the plan, make revisions, and implement the plan*).

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not (*e.g., recognize the usefulness of being skilled at mathematics and problem solving; appreciate how scientific problem solving and the development of new technologies are related*).

Interest in Science

Students will be encouraged to:

- show a continuing and more informed curiosity and interest in science and science-related issues (*e.g., demonstrate interest in science and technology topics not directly related to their formal studies*)

- consider further studies and careers in science- and technology-related fields (*e.g., explore where further science- and technology-related studies can be pursued*).

Scientific Attitudes

Students will be encouraged to:

- value the processes for drawing conclusions (*e.g., critically assess their opinion of the value of science and its applications*).

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas (*e.g., willingly work with any classmate or group of individuals, regardless of their age, gender, or physical and cultural characteristics; assume a variety of roles within a group, as required; accept responsibility for any task that helps the group complete an activity*).

Stewardship and Ethical Behaviour

Students will be encouraged to:

- have a sense of personal and shared responsibility for maintaining a sustainable environment (*e.g., willingly evaluate the impact of their own choices or the choices technologists make when they plan a project out an investigation; consider all perspectives when addressing issues, weighing scientific, technological and ecological factors*).

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations (*e.g., consider safety a positive limiting factor in scientific and technological endeavours; keep the work station uncluttered, with only appropriate laboratory materials present*).

Unit C: Flow of Matter in Living Systems *(Nature of Science emphasis)*

Overview: The fundamental unit of life, the cell, is an example of an efficient open system comprised of a cell membrane and organelles that carry out the basic functions of all living organisms. Students will infer that the study of cells and cellular processes has been enhanced by technological advancements in microscopy. The understanding of life processes at the microscopic level can also be applied to a multicellular organism. This unit, building upon Science 8, Unit B: Cells and Systems, extends the students understanding of cellular structure and function, and for multicellularity.

Focussing Questions: How did the cell theory replace the concept of “spontaneous generation” and revolutionize the study of life sciences? How do cells survive as a living organism? How do plants use specialized cells and processes to accomplish the same functions as a single cell, but on a larger scale? How does imaging technology further our understanding of the structure and function of cells?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- | | |
|--|---|
| ☆ microscopy and the emergence of cell theory | ☆ use of explanatory and visual models in science |
| ☆ cellular structures and functions, and technological applications | ☆ cell specialization in a multicellular organism; i.e., plants |
| ☆ active and passive transport of matter | ☆ mechanisms of transport, gas exchange, and environmental response in a multicellular organism; i.e., plants |
| ☆ relationship between cell size and shape, and surface area to volume ratio | |

STS and Knowledge Outcomes

Students will:

1. Explain the relationship between developments in imaging technology and the current understanding of the cell
 - trace the development of the cell theory: all living things are made up of one or more cells and the materials produced by these, cells are functional units of life, all cells come from preexisting cells (*e.g., from Aristotle to Hooke, Pasteur, Brown, and Schwann and Schleiden*)
 - describe how advancements in knowledge of cell structure and function have been enhanced and are increasing as a direct result of developments in microscope technology and staining techniques (*e.g., electron microscope, confocal laser scanning microscope [CLSM]*)
 - identify areas of cell research at the molecular level (*e.g., DNA and gene mapping, transport across cell membranes*).
2. Describe the function of cell organelles and structures in a cell, in terms of life processes; and use models to explain these processes and their applications
 - compare passive transport of matter by diffusion and osmosis with active transport in terms of the particle model of matter, concentration gradients, equilibrium, and protein carrier molecules (*e.g., particle model of matter and fluid-mosaic model*)
 - use models to explain and visualize complex processes like diffusion and osmosis, endo- and exocytosis, and the role of cell membrane in these processes
 - describe the cell as a functioning open system that uses processes involved in acquisition of nutrients, waste excretion, and exchange of matter and energy

- identify the structure and describe, in general terms, the function of the cell membrane, nucleus, lysosome, vacuole, mitochondrion, endoplasmic reticulum, Golgi apparatus, ribosomes, chloroplast and cell wall, where present, of plant and animal cells
 - compare the structure, chemical composition and function of plant and animal cells, and describe the complementary nature of the structure and function of plant and animal cells
 - describe the role of the cell membrane in maintaining equilibrium while exchanging matter
 - describe how knowledge about semi-permeable membranes, diffusion and osmosis has been applied in industry (*e.g., attachment of HIV drugs to cells and liposomes, diffusion of protein hormones into cells, staining of cells, desalination of sea water, peritoneal or mechanical dialysis, separation of bacteria from viruses, purification of water, cheese making, treatment of cancer*)
 - describe cell size and shape as they relate to the concept of surface area to volume ratio and how that ratio limits cell size (*e.g., compare nerve cells and blood cells in animals; plant root hair cells and chloroplast-containing cells on the leaf surface*) [**Prerequisite Skills: Grade 9 Mathematics, Strand: Shape and Space, SOs 5 and 6**].
3. Analyze plants as an example of a multicellular organism with specialized structures at the cellular, tissue and systems level
- infer how organism size necessitates the move to a multicellular level of organization and is related to the specialization of plant cells, tissues and systems
 - describe how the cells of the leaf system have a variety of specialized structures and functions; i.e., epidermis including guard cells, palisade tissue cells, spongy tissue cells, and phloem and xylem vascular tissue cells
 - explain and investigate the transport system in plants; i.e., xylem and phloem tissues and the processes of transpiration, including the cohesion and adhesion properties of water, turgor pressure and osmosis; diffusion, active transport, and root pressure in root hairs
 - explain and investigate the gas exchange system in plants; i.e., lenticels, guard cells and stomata, and the process of diffusion
 - explain and investigate phototropism and geotropism as examples of control systems in plants
 - trace the development of theories of phototropism and geotropism (*e.g., from Darwin and Boysen-Jensen to Went*).

Skill Outcomes (*focus on scientific inquiry*)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- define and delimit problems to facilitate investigation (*e.g., how do plants arrange root systems to accommodate different environmental conditions; how do plants react to varying levels of light, fertilizer, etc.*)
- design an experiment, identifying and controlling major variables (*e.g., design an investigation to determine the effect of CO_{2(g)} concentration on the number of chloroplasts found in an aquatic plant cell*)
- state a prediction and a hypothesis based on available evidence and background information (*e.g., hypothesize how biochemical interconversions of starch and glucose might regulate the turgor pressure of cells; hypothesize the direction of root and plant growth of a bean plant growing on a rotating turntable, and predict the effects of varying RPMs on the angle of growth*)

- identify the theoretical basis of an investigation, and develop a prediction and a hypothesis that are consistent with the theoretical basis (*e.g., use the particle theory to hypothesize the effect of different size particles on the rate of diffusion, and then predict the different action of a sucrose solution and a starch solution when placed in a dialysis tubing placed in a beaker of water*)
- formulate operational definitions of major variables (*e.g., define concentration gradient, equilibrium*).

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures where required (*e.g., perform an experiment to determine the effect of tonicity on plasmolysis and deplasmolysis in plant cells, such as staminal hairs or aquatic leaf cells, and identify variables such as amount of light, heat that does affect plasmolysis, and control these variables*)
- use instruments effectively and accurately for collecting data (*e.g., use a microscope to observe movement of water in plants; prepare wet mounts of tissue from flowering plants, and observe cellular structures specific to plant and animal cells; stain cells to make them visible*)
- estimate quantities (*e.g., compare sizes of various types of cells; calculate magnification, field of view and scale*) [**Prerequisite Skills: Grade 8 Mathematics, Strand: Number, SO 12 and Strand: Shape and Space, SO 11**]
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (*e.g., organize the data obtained from measuring daily temperature and bloom date of tree species such as Aspen, Poplar, common purple lilac and crocus to determine a relationship between the two variables*) [**Prerequisite Skill: Grade 8 Mathematics, Strand: Statistics and Probability, SO 3**]
- use library and electronic research tools to collect information on a given topic (*e.g., upload and download text, image, audio and video files on emerging technologies to study cells*)
- select and integrate information from various print and electronic sources or from several parts of the same source (*e.g., create multiple-linked documents or summarize articles based on the scientific principles and/or technological developments*).

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compile and display, by hand or computer, evidence and information in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots (*e.g., collect data on the number of stomata per unit area on various plant leaves that grow in areas of differing humidity, and compile this data on a spread sheet and graph it to determine whether there is a relationship between the variables*) [**Prerequisite Skills: Grade 9 Mathematics, Strand: Shape and Space, SOs 5 and 6**]
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables (*e.g., compare the surface area to volume ratio of various cells, and relate the findings to the cell's function*) [**Prerequisite Skills: Grade 9 Mathematics, Strand: Statistics and Probability, SOs 1 to 5**]
- provide a statement that addresses the problem or answers the question investigated, in light of the link between data and the conclusion (*e.g., observe and record macroscopic and microscopic changes in a growing plant for evidence of differentiation*)

- explain how data support or refute the hypothesis or prediction
- construct and test a prototype of a device or system, and troubleshoot problems as they arise (*e.g., create a model of a cell to perform a certain function, such as using a balloon with tape on it to represent a guard cell*)
- identify new questions or problems that arise from what was learned (*e.g., determine the purpose of cellular structures observed in living and prepared materials by use of dissecting and compound microscopes, or micrographs*).

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others (*e.g., describe the appearance of cytoplasmic streaming in a cell, and communicate the inference about similar movement in most cells of a multicellular organism*)
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results (*e.g., draw analogies between the evidence for division of labour within cells to services in communities; record and explain the movement of water in plants*).

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not (*e.g., appreciate how scientific problem solving and the development of new technologies are related; recognize the contribution of science and technology to the progress of civilizations*).

Interest in Science

Students will be encouraged to:

- consider further studies and careers in science- and technology-related fields (*e.g., investigate careers in fields such as botany, forestry, horticulture, cytology, genetics, laboratory technology, nephrology and public health*).

Scientific Attitudes

Students will be encouraged to:

- use factual information and rational explanations when analyzing and evaluating (*e.g., seek new models, explanations and theories when confronted with discrepant events*).

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas (*e.g., assume a variety of roles within a group, as required; evaluate the ideas of others objectively; accept responsibility for any task that helps the group complete an activity*).

Stewardship and Ethical Behaviour

Students will be encouraged to:

- want to take action for maintaining a sustainable environment (*e.g., willingly evaluate the impact of their own choices or the choices scientists make when they carry out an investigation*).

Safety

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations (*e.g., treat equipment with respect, and carefully manipulate materials*)
- be aware of the direct and indirect consequences of their actions (*e.g., assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials in a safe place*).

Unit D: Energy Flow in Global Systems *(Social and Environmental Contexts emphasis)*

Overview: Solar energy sustains life and drives the global climate systems on Earth. Without solar energy there would be no heat or precipitation and, therefore, life on Earth. Students will gain an understanding that the absorption and transfer of thermal energy at and near Earth's surface results in a variety of climate zones with characteristic weather patterns and biomes. Climatic factors determine the flora and fauna found in each of the world's major biomes. Using a variety of techniques, scientists have concluded there is a relationship between human activity and climate change – a change that could potentially harm the environment and our economy.

Focussing Questions: Are there relationships between solar energy, global energy transfer processes, climate and biomes? What evidence suggests our climate may be changing more rapidly than living species can adapt? Is human activity the cause for rapid climate change, and in meeting human needs, how can we reduce our impact on the biosphere and on global climate?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade levels. The intended level and scope of treatment is defined by the learning outcomes below.

- | | |
|--|--|
| ☆ social and environmental contexts for investigating climate change | ☆ hydrologic cycle and phase change |
| ☆ solar radiation budget | ☆ relationship between biomes and solar energy and climate |
| ☆ climatic zones, transfer of thermal energy by the hydrosphere and the atmosphere | ☆ human activity and climate change |

STS and Knowledge Outcomes

Students will:

1. Analyze the relationships among net solar energy, global energy transfer processes—primarily radiation, convection and hydrologic cycle—and climate, and the impact of climate on the lives of humans and other species
 - explain how climate profoundly affects the lives of people and other species in many ways, and explain the need to investigate climatic change (*e.g., describe the responses of human and other species to extreme climatic conditions on housing design and animal shelter, clothing and fur in conditions of extreme heat, cold, dryness/humidity, wind*)
 - investigate and describe, in general terms, the relationships among solar energy reaching Earth's surface and time of year, angle of inclination, length of daylight, cloud cover, albedo effect and dust particle distribution
 - analyze, in general terms, the net radiation budget, using percent; i.e., solar energy input, terrestrial energy output, net radiant energy [**Prerequisite Skill: Grade 8 Mathematics, Strand: Number, SO 13**]
 - describe, in general terms, how thermal energy is transferred through the atmosphere, (i.e., global wind patterns, jet stream, Coriolis effect, weather systems); and through the hydrosphere, (i.e., ocean currents, large bodies of water), from latitudes of net radiation surplus to latitudes of net radiation deficit resulting in a variety of climatic zones (*e.g., analyze static and animated satellite images*)
 - explain how thermal energy transfer through the atmosphere and hydrosphere affect climate
 - define the greenhouse effect, describe its causes; i.e., presence of CH_{4(g)}, CO_{2(g)}, H₂O_(g), and relate it to global warming

- investigate and explain how evaporation, condensation, freezing and melting transfer thermal energy; i.e., use simple calculations of heat of fusion $H_{fus} = \frac{Q}{n}$ and vaporization $H_{vap} = \frac{Q}{n}$, and $Q = mc\Delta t$ to convey amounts of thermal energy involved and link these processes to the hydrologic cycle [Prerequisite Skills: Grade 8 Mathematics, Strand: Patterns and Relations, SOs 4 to 6].
- Analyze the relationships among input solar energy, output terrestrial energy, energy flow within the biosphere and the characteristics of biomes
 - list and describe the three major components of Earth's biosphere—the atmosphere, the hydrosphere and the lithosphere
 - explain why a biome is an open system in terms of its components, such as input and output of energy and matter and changes in its boundaries
 - compare and contrast cells and biomes as open systems
 - relate and analyze the characteristics of climatograms of two major biomes; i.e., grasslands, desert, tundra, taiga, deciduous and rain forest, to net radiant energy and climatic factors; i.e., temperature, moisture, sunlight and wind, and explain why biomes with similar characteristics can exist in different geographical locations, latitudes and altitudes.
 - Analyze the impact of change in global energy transfer systems on humans and the biosphere
 - analyze the impact of human actions on biomes that have a potential to change climate (e.g., *emission of greenhouse gases, draining of wetlands, forest fires, deforestation*)
 - describe the role of science in furthering the understanding of climate and climate change through international programs (e.g., *World Meteorological Organization: World Weather Watch, World Climate and Global Atmosphere Watch, Surface Heat Budget Arctic (SHEBA), Ocean Project, The Intergovernmental Panel on Climate Change (IPCC); the study of paleoclimates to test models is being used to make policy decisions for future climate scenarios*)
 - use information and communication technology, and describe, in general, the role of technology in furthering the understanding of climate and climate change (e.g., *computer models, measurements of greenhouse gases, satellite imaging technology*)
 - describe the limitations of scientific knowledge and technology in making predictions related to climate and weather (e.g., *the direct and indirect impacts on Canada's agriculture, forestry and oceans resulting from climate change, or resulting from changes in energy transfer systems, such as ocean currents and global wind patterns*)
 - describe and analyze the evidence for and against rapid climatic change brought on by human activity (e.g., *global warming, deforestation, changing biomes, rising sea levels*)
 - assess, from a variety of perspectives, the risks and benefits of human activity and its impact on the biosphere and the climate (e.g., *Gaia hypothesis, native beliefs, economic perspectives, describe how rapid climatic change may result in population shifts and economic turmoil*).

Skill Outcomes (focus on applying science to inform decision-making processes)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- identify questions to investigate that arise from practical problems and issues (e.g., *develop questions related to global warming, such as "What will be the impact of global warming on Canada's northern biomes?"*)
- design an experiment, and identify specific variables (e.g., *investigate the heating effect of solar energy, with variables being temperature, efficiency, and materials used*)

- formulate operational definitions of major variables (*e.g., define heat of fusion or vaporization as amount of energy to change state of matter at melting or boiling points per unit mass in the absence of temperature change*).

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures where required (*e.g., perform an experiment to determine the ability of various materials to absorb or reflect solar energy*)
- use instruments effectively and accurately for collecting data (*e.g., use a barometer, rain gauge, thermometer, anemometer*)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (*e.g., organize data to prepare climatograms for comparing biomes*)
- use library and electronic research tools to collect information on a given topic (*e.g., research sources of greenhouse gases; research protocols to control human sources of greenhouse gases*)
- select and integrate information from various print and electronic sources or from several parts of the same source (*e.g., collect weather data, both historic and current, from the Internet*).

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compile and display, by hand or computer, evidence and information in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots (*e.g., construct climate graphs to compare any two of: grasslands, deserts, tundra, taiga, deciduous and rain forests*)
- identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information (*e.g., investigate the issue of global climate change*)
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables (*e.g., analyze a graph of mean monthly temperatures for cities of similar latitudes but different climate*)
- identify limitations of data, evidence or measurement (*e.g., list the limitations of data and evidence for past changes to climate*)
- provide a statement that addresses the problem or answers the question investigated, in light of the link between data and the conclusion (*e.g., summarize an analysis of the relationship between human activity and changing biomes*)
- explain how data support or refute the hypothesis or prediction (*e.g., provide evidence for or against human activity being responsible for climate change*)
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (*e.g., design a home for a specific climate*).

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results (*e.g., use appropriate SI notation, fundamental and derived units, and significant digits*) [**Prerequisite Skill: Grade 8 Mathematics, Strand: Number, SO 14**]
- synthesize information from multiple sources or from complex and lengthy texts, and make inferences based on this information (*e.g., use integrated software effectively and efficiently to reproduce work that incorporates data, graphics and text*)
- identify multiple perspectives that influence a science-related decision or issue (*e.g., consult a wide variety of electronic sources that reflect varied viewpoints and economic, social and scientific and other perspectives on global warming*)
- develop, present and defend a position or course of action, based on findings (*e.g., a strategy to reduce greenhouse gas emissions arising from the transport of people and goods*).

Attitude Outcomes

Appreciation of Science

Students will be encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not (*e.g., recognize the usefulness of static and moving satellite imagery to investigate climate and in predicting weather phenomena; recognize the contributions of the study of climate over time to making predictions about future climate change*)
- appreciate that the applications of science and technology can raise ethical dilemmas (*e.g., recognize that human actions may affect the sustainability of biomes for future generations*).

Interest in Science

Students will be encouraged to:

- show a continuing and more informed curiosity and interest in science and science-related issues (*e.g., express interest in science and technology topics not directly related to their formal studies*).

Scientific Attitudes

Students will be encouraged to:

- evaluate evidence confidently, and consider alternative perspectives, ideas and explanations (*e.g., collect evidence, ask questions, do research*)
- use factual information and rational explanations when analyzing and evaluating (*e.g., critically evaluate inferences and conclusions, free of bias, being cognizant of the many variables involved in experimentation*)
- value the processes for drawing conclusions (*e.g., critically assess their opinion of the value of science and its applications*).

Collaboration

Students will be encouraged to:

- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas (*e.g., assume a variety of roles within a group, as required; accept responsibility for any task that helps the group complete an activity; seek the point of view of others, and consider a multitude of perspectives*).

Stewardship and Ethical Behaviour

Students will be encouraged to:

- have a sense of personal and shared responsibility for maintaining a sustainable environment (*e.g., participate in civic activities related to the preservation and judicious use of the environment and its resources; consider all perspectives when addressing issues, weighing scientific, technological and ecological factors; remain critical-minded regarding the short- and long-term consequences of sustainability*)
- project the personal, social and environmental consequences of proposed action (*e.g., consider all perspectives when addressing issues, weighing scientific, technological, ecological and other factors*)
- want to take action for maintaining a sustainable environment (*e.g., encourage their peers or members of their community to participate in a project related to sustainability; participate in the social and political systems that influence environmental policy in their community*).

Safety

Students will be encouraged to:

- be aware of the direct and indirect consequences of their actions.

